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Period: August 1, 1963 through January 31, 1964

Submitted by

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Principal Investigator

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→ [Statistical ... Activity]

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Abstract

A

A series of observations of the polarization of radiation from Jupiter has been made at frequencies of 16, 18, 22 and 26 Mc/s. Some 3,800 noise bursts have been analyzed and a detailed account has been prepared. In general, for the period of the observations, almost all of the radiation at 22 and 26 Mc/s was right-handed polarized (R.H.) whereas at 16 and 18 Mc/s an appreciable proportion of bursts were L.H. In particular, events observed when $300 < \lambda_{III} \leq 360$ (I.A.U. revised System III) were found to contain, respectively, 41% and 30% L.H. bursts at 16 and 18 Mc/s. A comparison of the results with the predictions of the Doppler-shifted cyclotron theory of Ellis and McCulloch (1) is now in progress.

A series of spaced-site observations from three sites has been completed and analysis is in progress. A new experiment to investigate the possibility of terrestrial ionospheric modification of the radiation is to be conducted from existing funds this year.

A number of high-speed recordings of 18 Mc/s events have been made at the request of the University of Florida group and these have been sent to Gainesville for comparison with similar records taken at that site.

Plans are being prepared for a new, higher-sensitivity improved discrimination, polarimeter system to be submitted for evaluation by NASA in due course.

AUTHOR

1. Polarization

In the investigation of polarization of decametre-wave radiation from Jupiter a series of observations were made covering the period, July 13, through December 5, 1963, and a first analysis of the data has been completed. This was reported at a recent meeting of the American Geophysical Union (Boulder, Colorado, December 28, 1963). A detailed account entitled "Polarization Observations of Jupiter at Decametre-Wavelengths" (Barrow (2)) is enclosed with this report. Some 3,800 noise bursts from Jupiter, at frequencies of 16, 18, 22 and 26 Mc/s, have been studied in detail.

Axial ratios have been computed for each burst, assuming complete polarization, and an analysis, similar to that made for 10.1 Mc/s observations by Dowden (3), is in progress, so that the results may be compared with the Doppler-shifted cyclotron theory of Ellis and McCulloch (1). This is illustrated in Figures 1-4. The two lower frequencies are of greatest interest as it is at 16 and 18 Mc/s that appreciable proportions of L.H. polarized bursts have been observed. Also, there are more bursts available for analysis (See Reference 2, Table 2) at these frequencies. The 22 and 26 Mc/s computations have been made for the sake of completeness but they do not contribute anything very conclusive to the discussion and are not included in the diagrams.

In Figure 1 the distributions of axial ratios are compared with the observations of Dowden (3). The 18 Mc/s results, in particular, are in very good agreement with the distribution predicted by the Ellis and McCulloch theory (shown in Figure 2) and the 16 Mc/s results are reconcilable if we accept Dowden's suggestion that the lower axial ratios are produced by superimposed bursts of higher axial ratio but opposite sense. It is the shape of the distribution which is significant. The position on the axial ratio scale depends upon the assumed model of Jupiter rather than on the theory.

In Figure 3 the smoothed occurrence rates of L.H. and R.H. bursts are compared. In Figure 4 the smoothed longitude variations of burst occurrence is shown. According to Dowden's results this latter may also be regarded as an indication of the distribution of total power radiated.

The Ellis and McCulloch theory (1) seeks to explain the experimentally observed longitude profiles of occurrence probability and power distribution. A suitable choice of magnetic field anomaly, expressed as a dip anomaly, readily produces the differing profiles observed at 5 and 10 Mc/s compared to those found at higher frequencies. So the histograms presented here (Figures 5 and 6) as well as the burst distribution (Figure 4) are, by definition, consistent with

the theory. The axial ratio distributions shown in Figure 1, particularly at 18 Mc/s, are in good agreement with the predictions of the theory and are therefore the most significant experimental evidence in its favor.

In view of the already established results explained by the theory as well as the polarimeter data, it is felt that this theory offers the most satisfactory explanation of the origin and escape of the decametric radiation to date. It is perhaps significant that, unlike most theories that have been proposed, the Doppler-shifted cyclotron theory seeks to explain the radiation in terms of characteristics which are known to occur on a different scale within the atmosphere of the Earth. It will be interesting to see if the satellites proposed for studying VLF emission from the Earth find evidence of any longitude profile of radiated power due to the Earth's ~~magnetic~~ field.

When the study of polarization at different frequencies was originally proposed it was hoped that a simple magneto-ionic interpretation of the data, in the manner outlined in Reference 2, Section VI, would lead to values of Jovian ionospheric parameters. However, it was tacitly assumed by the writer (4), and by others (5) that, in the absence of other information the radiation was generated in both magneto-ionic modes.

Subsequent work, and in particular the association of Jupiter activity with solar activity, now makes this seem less likely. The theory of Ellis and McCulloch (1) is, therefore, preferred to the simple magnetic-ionic interpretation.

2. Spaced-site Experiments.

In the spaced-site experiment, observations of Jupiter were made at 18 and 22 Mc/s from July to December, 1963 at Florida State University Radio Observatory in Tallahassee, the out-station at the Hyde Radio Observatory, St. Osyth, England and by collaborators at Rhodes University in South Africa. All of the data obtained has now arrived at Florida State University, and analysis is in progress. Correlation coefficients between Jupiter activity and various indications of solar activity are being computed for a first examination of the data. The combined observations at 18 Mc/s are shown in Figure 5. It is interesting to note that progressively lower occurrence probabilities have been observed at the three sites from south to north respectively. While there are differences in the identification procedure adopted by the group in South Africa as well as differences in the local noise level at each site, these are hardly enough to produce the pronounced effect observed. It is suggested that terrestrial ionospheric modification of the radiation is responsible

and an experiment to operate from existing grant and supplement funds, has been planned to investigate this during the 1964 apparition of Jupiter. It is worth noting that simple magneto-ionic absorption may be insufficient to account for all of this effect, even at lower incidence angles, as the observing frequency of 18 Mc/s is considerably higher than the critical frequency during the early morning hours at sunspot minimum when all the observations were made.

High speed recordings of Jupiter noise storms were taken at Tallahassee using the 18 Mc/s corner-reflector, and these are to be compared with similar observations made by the University of Florida group 150 miles away. Some twenty suitable records have been sent to Mr. Carl Olsson at the University of Florida at whose request the observations were made.

3. The search for radiation at 42 Mc/s has produced inconclusive results as observations have been hampered by noisy conditions due to local police broadcasts outside the allotted frequency band.

4. Future Plans.

The observations of polarization made during 1963 have indicated very clearly what the approach for the

future should be. More data at frequencies below 18 Mc/s is needed and an urgent requirement is that the data should be handled automatically rather than semi-manually as has been done to date. It appears from the work of Stone, Alexander and Erickson (6)* that a higher sensitivity system will achieve the necessary increase in the amount of data and may also lead to interesting features in the corresponding longitude profile. At 26.3 Mc/s it appears that the histogram peaks are broadened while the well defined zero persists. It is felt that future effort should be directed towards two antenna systems, operating at 18 Mc/s and some lower frequency, each consisting of two large arrays of crossed dipoles. Some form of computer-fed digital output is highly desirable both for consistency and for ease of handling the large amount of data that should appear with the greater sensitivity. By the use of two separated arrays it should be possible to reduce uncertainties due to the terrestrial ionosphere by imposing the condition that a burst must show similar form and polarization to be regarded as a proper indicator of conditions at Jupiter. It would also be desirable to attempt to obtain a complete

* I am most grateful to Dr. R. G. Stone for permission to refer to his work prior to publication.

specification of the polarization by measurement of all four of the Stokes parameters (see, for example, Cohen (7)) although Faraday rotation in the Earth's ionosphere imposes considerable uncertainty on this procedure at low frequencies. A design is being prepared by the Principal Investigator and will be submitted for evaluation by NASA in due course.

The possibility of terrestrial ionospheric modification of the radiation is to be studied further during 1964 by a new experiment at 18 Mc/s. Arrangements have been made to set up a north-south line of separated antennas at the following locations:-

University of Ibadan, Nigeria, West Africa

University of Valencia, Spain

F. S. U. out-station, at the Hyde Radio Observatory,
England

University of Bergen, Norway.

Mosley Electronics, Inc., are supplying Yagi antenna systems with steering mechanisms and self-supporting towers. The total cost of the experiment including equipment, operating personnel and associated travel will be about \$13,000. This is to be met from existing grant and supplement funds.

Simultaneous observations will be made from each site during the 1964 apparition so that any systematic modification of the radiation observed towards northerly terrestrial latitudes will become apparent.

References:

1. Ellis, G. R. A. and McCulloch, P. M., Aust. J. Phys., 16, 380 (1963)
2. Barrow, C. H., "Polarization Observations of Jupiter at Decameter-Wavelengths"
Paper presented at A.G.U. Meeting, Boulder, Colorado, December 28, 1963. (Copy accompanies this report).
3. Dowden, R. L., Aust. J. Phys., 16, 398 (1963).
4. Barrow, C. H., Nature, 188, 924 (1960).
5. Franklin, K. L. and Burke, B. F., J. Geophys. Res., 63, 807 (1958).
6. Stone, R. G., Alexander, J. K., Erickson, W. C., Astrophys. J., In press (1964).
7. Cohen, M. H., Proc. I. R. E., 46, 172 (1958).

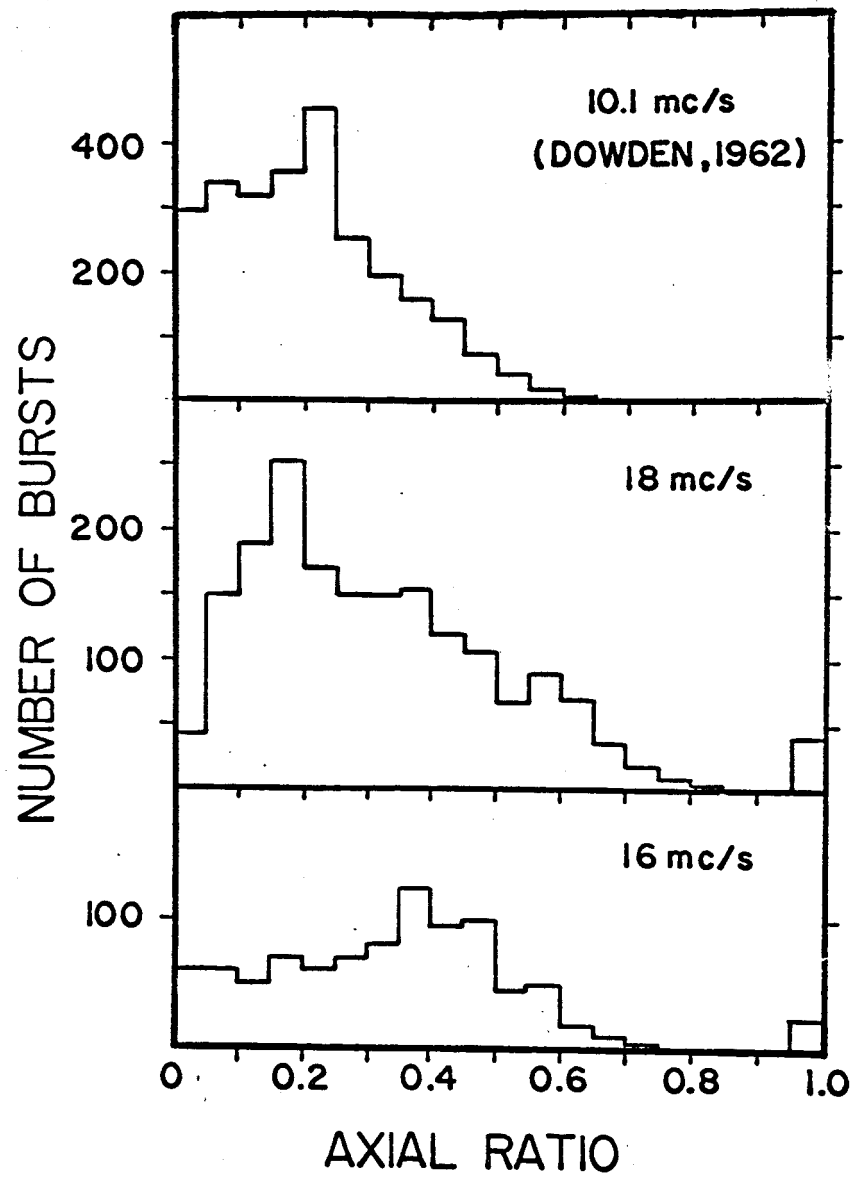


Figure 1.

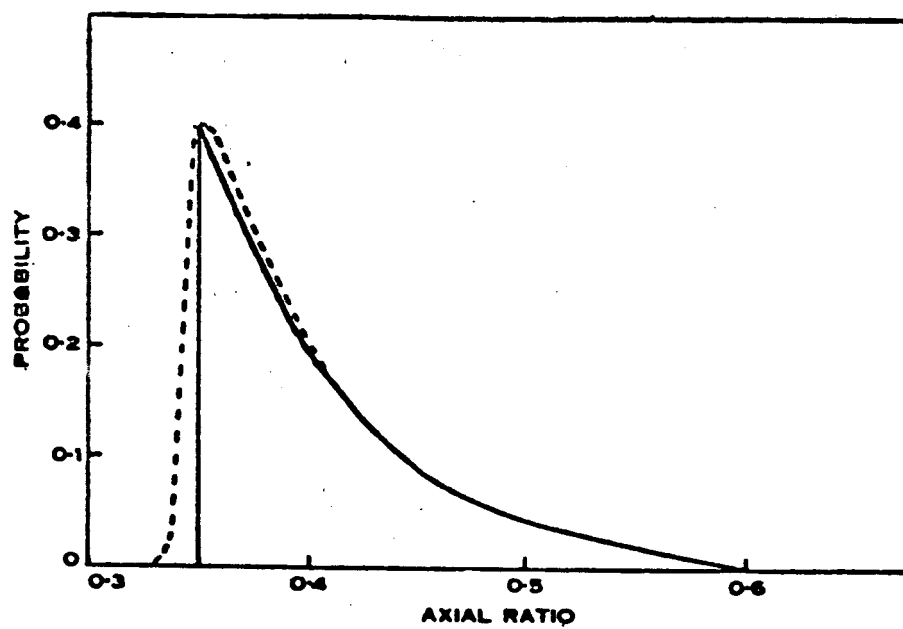


Figure 2.

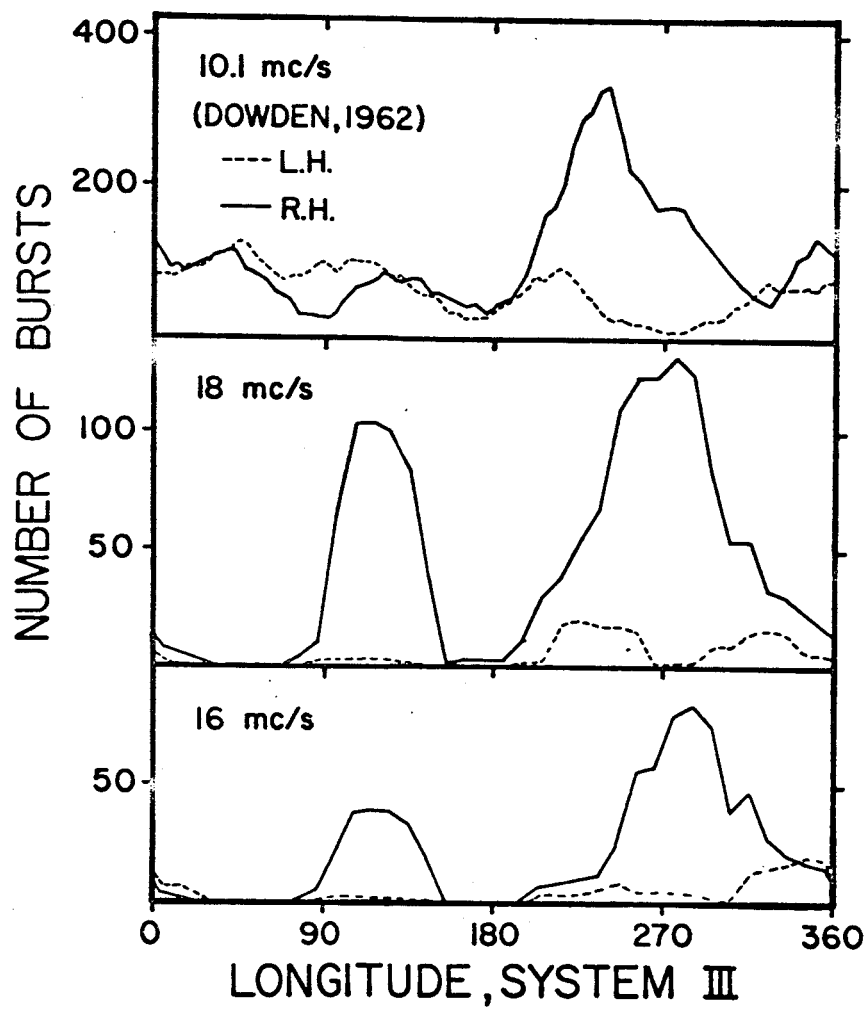


Figure 3.

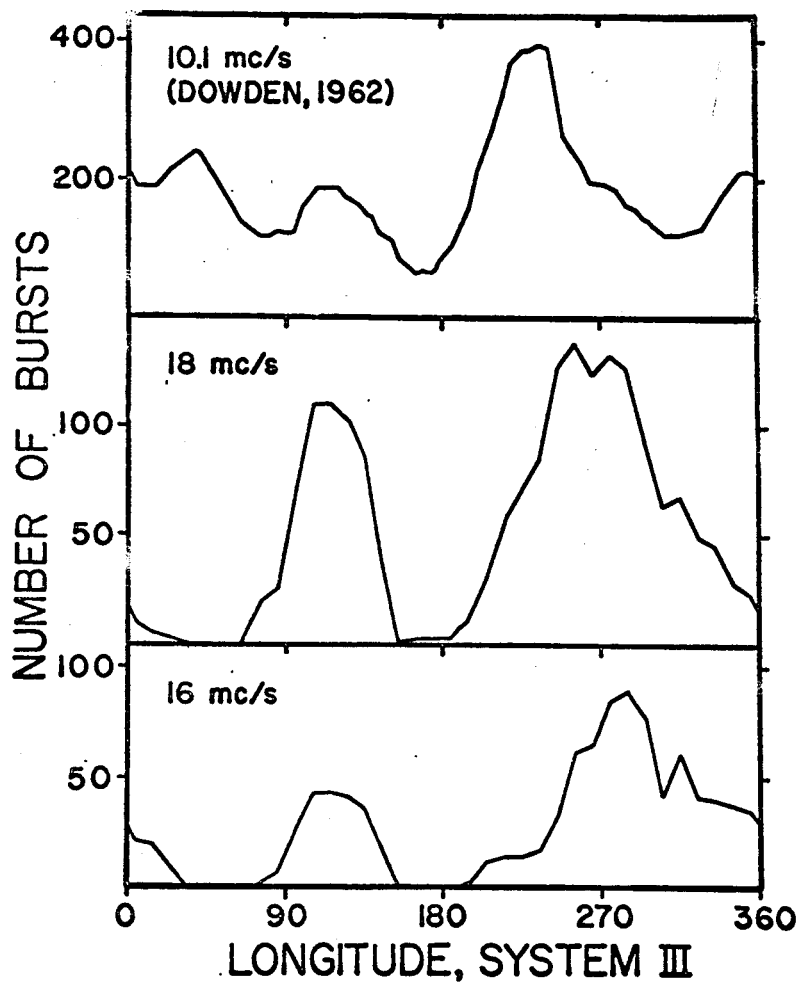


Figure 4.

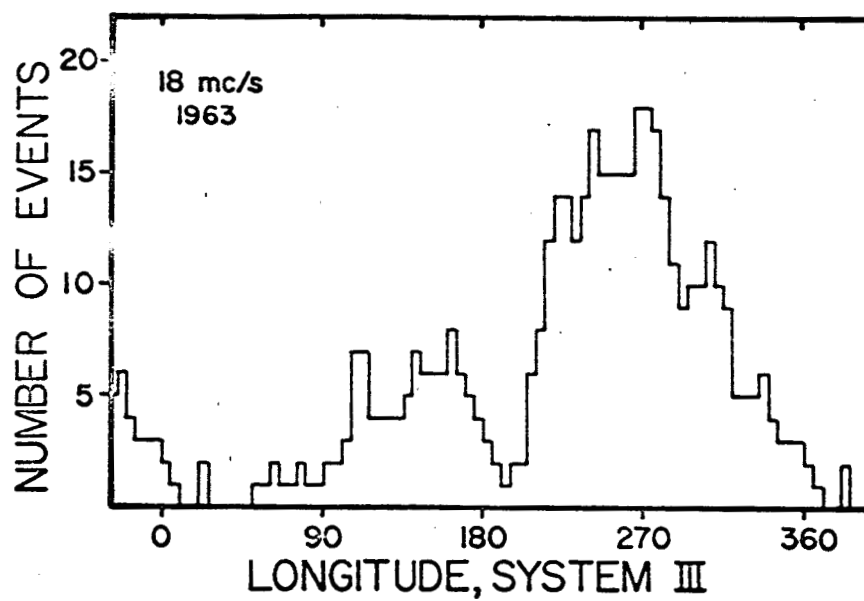


Figure 5.

List of Figures.

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2. Axial ratio distribution predicted by the Doppler-shifted cyclotron theory of Ellis and McCulloch (1).
3. Smoothed occurrence rate of L.H. and R.H. bursts.
4. Smoothed longitude variation of burst occurrence rate.
5. Histogram showing the total number of events observed at 18 Mc/s at Tallahassee, St. Osyth and Grahamstown during the period July 17 through November 25, 1963.

5. Publications: August 1, 1963 to January 31, 1964

- ✓ 1. "A Note on the Polarization of 16 Mc/s Radiation from Jupiter,"
Barrow, C. H., *Nature*, 201, 171 (1964)
- ✗ 2. "An Experiment to Study the Relationship between Radio Noise from Jupiter and Solar Activity,"
Barrow, C. H. and Hyde, F. W.
J. Brit. Ast. Assn., 23, 327 (1963)
- ✗ 3. "Decameter-Wave Observations of Jupiter in 1963,"
(Abstract)
Barrow, C. H., *Bull. Am. Phys. Soc.* (In press)
- ✓ 4. "Polarization Observations of Jupiter at Decameter-Wave Frequencies," (Abstract)
Barrow, C. H., *Trans. A. G. U.*, 44, 887 (1963)
- ✓ 5. "Polarization Observations of Jupiter at Decameter-Wavelengths,"
Barrow, C. H., submitted to *Icarus*, 1964.
- ✗ 6. "Mysterious Radio Emissions from the Planet Jupiter,"
Hyde, F. W., *New Scientist*, 19, 432 (1963)
- ✗ 7. "Radio Astronomy"
Hyde, F. W., *J. Soc. Engr's.*, 14, 195-221 (1963)
- ✗ 8. Practical Amateur Astronomy, (Lutterworth Press, London, 1963)
Chapter 19, pp. 222-234. Hyde, F. W.
9. 1964 Astronomical Year Book, (Eyre and Spottiswoode, London, 1964) Chapter entitled "The Radio Sun" in press.

In Preparation

A paper comparing the experimental results with the predictions of the Doppler-shifted cyclotron theory.
Barrow, C. H.

Talks given during the Period:

C. H. Barrow

"Decameter-Wave Observations of Jupiter in 1963,"
S.E.A.P.S. Meeting, Lexington, Kentucky, (November 9, 1963)

"Polarization Observations of Jupiter at Decameter-Wave
Frequencies,"
A.G.U. Meeting, Boulder, Colorado, (December 28, 1963).

Colloquia

Department of Physics, Virginia Polytechnic Institute,
January 7, 1964.

Department of Physics, University of the West Indies,
January 24, 1964.

F. W. Hyde

"Radio Astronomy,"
Society of Engineers, London, England (October 7, 1963)
(Awarded Simms Gold Medal and Fellowship of the Society) --
see also under Publications.

Lectures on "Techniques and Spaced-site Experiments,"
Radio Society of Great Britain, South, Southwest, East
and London Regional Meetings.

Various popular level magazine features radio and
television broadcasts

6. Personnel Working on the Grant:

(a) Tallahassee

C. H. Barrow, Assistant Professor and Principal
Investigator

*E. J. Seykora, Graduate Assistant

G. M. Resch, Graduate Assistant

J. H. Cocke, Electronics Technician

*H. W. Meier, Undergraduate Assistant

*J. Merritt, Undergraduate Assistant

G. R. Adcock, Undergraduate Assistant

N. E. Thagard, Undergraduate Assistant

H. Rolleston, Undergraduate Assistant

* Terminated during the period.

(b) St. Osyth

F. W. Hyde, Director of St. Osyth station (Self supported).

D. Crosswell, Part-time Secretary

R. Hawkins, Undergraduate Assistant

R. Womble, Undergraduate Assistant

P. Morris, Undergraduate Assistant

G. Coleman, Undergraduate Assistant

Personnel Associated with the Project.

(a) Grahamstown, South Africa

J. A. Gledhill, Professor of Physics and Director of Radio Astronomy

G. M. Gruber, Graduate Assistant

(b) Local supervisors for the 1964 spaced-site observations.

A. J. Lyon, Professor of Physics, University of Ibadan

J. Catala, Professor of Physics, University of Valencia

B. Trumphy, Professor of Physics, University of Bergen.